APPENDIX O

ALERT LEVEL CALCULATIONS FOR LEAK COLLECTION AND REMOVAL SYSTEMS
AQUIFER PROTECTION PERMIT APPLICATION
GUNNISON COPPER PROJECT

COCHISE COUNTY, ARIZONA

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1. INTRODUCTION

This attachment includes Alert Level (AL) calculations for the Leak Collection and Removal Systems (LCRS) installed in APP-permitted impoundments for the Gunnison Copper Project. Six APP-regulated impoundments (Raffinate Pond, PLS Pond, Recycled Water Pond, Evaporation Pond, and Solids Impoundment Facilities 1 and 2) will be constructed with LCRSs. Each of these facilities will consist of a double liner with a leak collection layer and sump between the liners as described in the BADCT demonstration section of the APP Application. The ALs are equivalent to potential leakage rates (PLRs) calculated based on the design parameters of each facility (depth of solution in the pond and area of the pond) and expected leakage for installed liners.

2. EQUATIONS

The PLRs for a liner can be determined using Bernoulli's equation for free flow through an opening. The equation is shown below

$$Q = C_B a \sqrt{2gh_w}$$

Where:

Q = Rate of liquid migration or PLR through a hole (cubic meters per second [m^3/s])

C_B = Dimensionless coefficient related to the shape of the edges of the hole (sharp edges $C_B = 0.6$)

a = Hole area (square meters [m^2])

g = Acceleration due to gravity (9.8 meters per second squared [m/s^2)]

h = Liquid depth on top of the liner (meters [m])

3. CALCULATIONS

3.1 Assumptions

Giroud and Bonaparte (1989) estimate that one 2-millimeter (mm) hole can be expected in every acre (ac) of liner under normal operating conditions. The estimate assumes the holes are due to seam defects that are not detected by the construction quality assurance program.

3.2 Results

The pond parameters are tabulated below. Each of the Solids Impoundment Areas contains two cells. An AL was calculated for each cell of the Solids Containment Pond.

Facility	Depth (m)	Area of Pond (ac)
Raffinate Pond	6.1	2.25
PLS Pond	6.1	2.28
Recycled Water Pond	3.7	0.51
Evaporation Pond	2.4	5.56
Solids Cell 1A	10.1	7.16
Solids Cell 1B	10.1	7.16
Solids Cell 2A	10.1	7.16
Solids Cell 2B	10.1	7.16

As discussed in Section 2, a value of 0.6 was used for C_B and 9.8 m/s^2 was used for g. Assuming a 2 mm hole, the hole area was 0.00000314 m^2. Using these variables, the PLR per defect was calculated as shown below.

Facility	Max Depth (m)	Area of Pond (ac)	PLR per Defect (m^3/s/defect)	PLR for Facility (m^3/s)	Proposed AL (gpd)
Raffinate Pond	7.0	2.25	2.20841E-05	0.000050	1,135
PLS Pond	7.0	2.28	2.20841E-05	0.000050	1,148
Recycled Water Pond	4.3	0.51	1.72298E-05	0.000009	201
Evaporation Pond	10.2	5.56	2.66526E-05	0.000148	3,382
Solids Cell 1A	10.1	7.16	2.64529E-05	0.000189	4,323
Solids Cell 1B	10.1	7.16	2.64529E-05	0.000189	4,323
Solids Cell 2A	10.1	7.16	2.64529E-05	0.000189	4,323
Solids Cell 2B	10.1	7.16	2.64529E-05	0.000189	4,323

Giroud and Bonaparte (1989) assume one defect per acre. Therefore the PLR per defect (shown in cubic meters per second per defect) was multiplied by the area of the facility to arrive at the PLR for each facility. The AL is equal to the PLR for each facility (shown in cubic meters per second), however it was converted to gallons per day (gpd) for ease of use. The conversion from m^3/s to gpd is as completed as follows:

$$\frac{1\ m^3}{s} \times \frac{60\ s}{1\ min} \times \frac{60\ min}{1\ hr} \times \frac{24\ hr}{1\ d} \times \frac{264\ gal}{1\ m^3} = 22,824{,}461 \times \frac{m^3}{s}$$

4. REFERENCES

Giroud, J.P., Bonaparte, R. (1989) Leakage through Liners Constructed with Geomembranes – Part II. Composite Liners. Geotextiles and Geomembranes. Elsevier Science Publishers Ltd, England, Great Britain. pp. 71-109.